Care Network Coordination for Chemotherapy at Home: A Case Study

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Abstract. This paper deals with a system of chemotherapy at home which is managed by a Home Care Services (HCS) structure. The main role of this HCS structure is to coordinate care actors for a smooth organization of chemotherapy at home. In this work, we model a real system of chemotherapy at home managed by a HCS structure, and simulate its behaviour. The objective is to evaluate the relevance of such a system for current activities of the HCS structure, and to propose solutions for improving the optimal coordination of the care network for chemotherapy at home.

Keywords: Care network coordination, Home Care Services, Cancer chemotherapy at home, Process modelling, Discrete event simulation

1 Introduction

The increased aging population is an important pressure to hospitals, which are heavily constrained by their resources to meet growing patient demands, especially for patients with severe acute illness and chronic conditions. The fact becomes a main motivation and explains the speed development of the Home Care Services (HCS) in France. The cancer chemotherapy at home occupies 15.6% of stays in HCS in 2006.

In this paper, we focus on cancer chemotherapy at home process by referring a real-word case study, which can be considered as a care network managed by a coordination center. The management performance depends greatly on quality and effectiveness of coordination. Therefore, we aim above all to understand the chemotherapy at home process and to identify the care actors' responsibility using process modelling method; and then to evaluate quality of coordination of the system using discrete event simulation. Based on previous results, we propose two improvement procedures, which are simulated. The simulation results are used for a comparative analysis.

The remainder of the article is organized as follows: In section 2, we give general information on the cancer chemotherapy at home. Section 3 describes the studied system of chemotherapy at home using process modelling method. Section 4 presents the simulation approach with three scenarios; the results of the study are also discussed. The article ends with a conclusion of our work.

2 Development of cancer chemotherapy at home

The French government encourages the development of chemotherapy at home in regarding it as one of the objectives of the Cancer Plan and the reorganization of oncology care (Urban, 2006).

Some existing research works [Dahan & al., 2007] [Boothroyd & al., 2004] show that chemotherapy at home is feasible, not only in terms of quality and safety of care, but also in terms of patients and their family satisfaction. Urban (2003) points that chemotherapy at home only suits valid patients, who are informed and integrated in a care program, and who are treated in a suitable family environment. Gorski & al. (2008) survey chemotherapy at home and other infusion therapies being realized at home; they indicate more clearly the advantages and disadvantages of these treatments, especially some critical success factors of their realization at home. Chahed & al. (2008) are interested in a drugs delivery problem for a chemotherapy at home system. Collomp & al. (2008) propose to use new technologies to facilitate the traceability management of products and care actors' activities in order to improve quality of care for chemotherapy at home. Some other researchers [HAS, 2005] [Launois, 1996] analyze the economic aspect of the chemotherapy at home and show that chemotherapy at home does not seem more expensive than its implementation in conventional hospitalization.

However practices of chemotherapy at home are not much in France, the same for research works surveying chemotherapy at home organization process. Our work helps to fill this gap.

3 Chemotherapy at home process modeling: a case study

In this work, we present a real world case study of the chemotherapy at home. The studied system is implemented by a HCS structure situated in the Rhône-Alpes province of France. The HCS structure exists for more than thirty years. Today, it treats about 250 patients per day, and its operation areas extend across the Rhône department and part of the Isere department. They began the chemotherapy at home activity in the early 90's. This activity represents nowadays 3% of the admissions of the studied HCS structure.

Using process modelling method, we analyze the system in detail and divide the process into three phases: patient admission phase, home care preparation phase and cure realization phase. We present here only the realization phase of chemotherapy at home because that is the focus of the whole system. At this stage, we can see different internal and external actors really involved for delivering cares or services for patients.

The realization process of chemotherapy at home takes here three days; the most important activities are only concentrated in the first two days. The last day is used for the follow-up post chemotherapy that could be usually carried out by a coordinator nurse by phone, or occasionally by a private nurse with a home visit if necessary. A simplified model of the process is shown in Figure 1. We simulated the studied system based on this model for evaluating system performance. The simulation approach and results will be discussed in the next section.

3.1 Realization process for chemotherapy at home

The first day of the realization process is devoted to chemotherapy cure validation and drugs preparation. Above all, patient's blood sample has to be analyzed; blood sample could be taken by a private nurse or by a city biological laboratory, at patient's home or in the laboratory. And then, the city biological laboratory ensures blood analysis and transfers the results to the HCS structure, patient's family doctor and his hospital. The family doctor plays a role of evaluator by understanding the results and permitting or not chemotherapy cure realization. If results are normal, the family doctor visits the patient at his home and gives chemotherapy validation in signing a written order depending on patient's physical conditions. The validated written order is named "Clinical Green Light" (CGL) and will be transmitted to the HCS structure by fax. It is received by a coordinator nurse, especially allocated for the chemotherapy at home activity. The coordinator nurse shows the CGL to a coordinator doctor in order to obtain the final validation of the cure at home, named "Final Green Light" (FGL). The FGL is then transferred to the pharmacy of the HCS structure and verified by a pharmacist in terms of chemotherapy drugs dosage. The pharmacist gives his agreement for drugs preparation by fax with the signed FGL to a contracted hospital pharmacy which will prepare chemotherapy drugs corresponding to the defined dosage. Simultaneously, pharmacy of the HCS structure ensures other necessary medicines preparation. Ideally, chemotherapy drugs production should be finished in the first day in late afternoon; in cases of delays, this production must be performed in emergency on second day of the process in early morning.

During the second day of program, a staff delivery person of the HCS structure takes firstly the necessary medicines prepared by the HCS structure's pharmacy, then chemotherapy drugs at the hospital pharmacy, and transports them together to patient's home. Delivery verification will be done by an assigned private nurse after his arrival at patient's home. He hereafter prepares the patient for treatments and administrates chemotherapy drugs one by one. Treatment durations vary according to prescribed chemotherapy protocols. At the end of the cure, the private nurse stays with patient for a certain period of time for surveillance.

3.2 Coordination design presentation

By looking at the simplified model illustrated in Figure 1, we can observe that coordination is necessary all around the realization process. It is ensured by a coordinator doctor and a coordinator nurse belonging to the studied HCS structure.

The coordinator doctor plays here just a role of supervisor, by overseeing medical operations and chemotherapy protocols performance. However, the coordination tasks done by the coordinator nurse are very significant for the quality assurance of the realization process; she links the different actors (HCS structure, private nurse, city biological laboratory, family doctor, hospital pharmacy, …) delivering cares or services to a patient, and follows the accomplishment of their activity, accelerating them in case of forgetfulness, mistakes and delays.

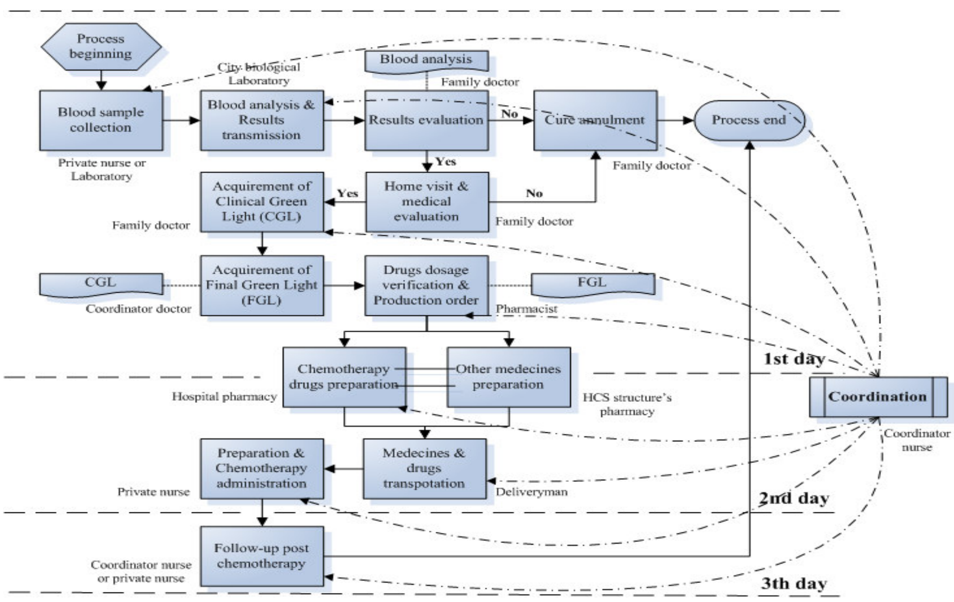

Fig. 1. Realization process of chemotherapy at home of the studied HCS structure

Obviously, the coordinator nurse is deemed as core of the chemotherapy at home system, especially for the first two days of the realization process, during which various activities must be achieved by different external actors, within a limited time. The coordinator nurse must ensure a good sequence for these activities, and an efficient communication.

In the studied system, the main activities are carried out by external actors, but coordination is principally guaranteed by a staff nurse of the HCS structure. We thus define this system as chemotherapy at home system managed by a coordination center.

4 Simulation approach and results

Discrete event simulation is a good method for resolving performance evaluation and coordination problems. Using this method, we evaluate in this section the studied system's performance, and propose improvement procedures.

The presented chemotherapy at home system, managed by a coordination center, seems flexible and simple to pilot, but the system performance depends hardly on the quality of coordination. Our aim here is to use simulation in order to evaluate firstly the quality of coordination for a real system; results are then compared to those of two proposed improved scenarios. We restrict our simulations to the first two days of the realization process, because they need more coordination tasks, due to the presence of concentrated activities.

4.1 Experiment configuration and validation

The proposed simulation model, built basing on the realization process of chemotherapy at home (Figure 1), includes not only the different necessary activities for chemotherapy at home realization, the coordination tasks being ensured by the coordinator nurse, but also the uncertainty on the accomplishment dates for some activities and decision-making fulfilled by external actors. Data used for building simulation model are collected and calculated from direct field observation and interviews with care actors.

The entities are created according to an analysis of a six months' patient treatment program. Seven chemotherapy protocols are considered. Two hospital pharmacies are available for chemotherapy drugs preparation, and one ensures more activities than the other. Patients' homes are dispersed in an area of 80 km around the studied HCS structure.

Performance indicators chosen for the evaluation of coordination quality are the coordination time spent by coordinator nurse and the effect of the coordination design on chemotherapy at home organization.

The experiment period is fixed to three months, and we use a 95% confidence interval to validate the relevance of the simulation model. Operation durations of key activities are seen as validation factors. Taking into account the stochastic aspects related to distribution laws, the simulation model is validated with 30 replications for offering reliable results.

4.2 Simulation scenarios description

The first simulation scenario concerns actual chemotherapy at home system of the studied HCS structure (***Scenario 1***), in which different external actors ensure only their activities for chemotherapy at home realization, but not the communication with the HCS structure. Coordination is initialized by coordinator nurse who follows activities' progress and accelerates external actors if necessary, usually by phone. The coordination design is supported by a manual way.

The first improvement solution we propose (***Scenario 2***) consists in modifying the coordination design by redefining actors' responsibility and eliminating superfluous tasks. On the one hand, all the external actors participate to coordination tasks; they should inform achievement of their activities to coordinator nurse on their own initiative. Instead of verifying, informing and accelerating external actors, the coordinator nurse ensures nothing more than information reception and transmission by phone or fax. On the other hand, we notice in the actual model (Figure 1), that some tasks are performed twice successively, by two competent actors: chemotherapy at home cure is validated by both, the family doctor and the coordinator doctor; chemotherapy drugs dosage is verified by the pharmacist of the HCS structure and then by hospital pharmacy. We propose here to keep only one actor for each task: family doctor for cure validation and hospital pharmacy for drugs dosage verification.

In the ***Scenario 3***, we recommend the use of new information and communication technologies (NICT) to replace the manual way of coordination. Applications of NICT in the home care domain are already approved by the literature [Koch, 2006] [Collomp & al., 2008] [Tan & al., 2002] [Maglaveras & al., 2002]. In this second improvement procedure, we propose a framework of a traceability management of actors' activities, in which several actors are connected by cable network and others by mobile network. Patient records are stored in a central server and could be shared between different care actors. Information transfers become automatic, accompanied by an alert to recipient. The HCS structure, city biological laboratory and hospital pharmacy are connected to central server by cable network. A mini pocket pc should be assigned to each patient across mobile network. The validation tasks could be done by electronic signature that permits the automatic transfer of the necessary information to the predetermined recipient. For private nurse and family doctor, their electric signatures could be done using the pocket pc assigned to patient. Thus, patient has the responsibility to carry the pocket pc always with him for the treatments and to provide it to certain care actors (i.e. private nurse, family doctor) if necessary.

4.3 Results analysis

In this subsection, we present the results obtained thanks to the simulation of the three scenarios described above. A comparative analysis enables to determine the most optimal coordination design. The used comparison indicators are coordination time spent by coordinator nurse during experiment period for each patient, realization time used by each external actor for achieving his activity, and delay ratio depending on realization time constraint. For laboratory and family doctor, the realization time is composed by an operation time and a variable waiting time before activity execution. Results of comparative analysis are showed in Table 1 and Table 2.

Table 1. Comparative analysis in terms of coordination time between 3 scenarios

Scenario	Number of patient	Coordination time per patient
Scenario 1	60	47 minutes
Scenario 2	66	32 minutes
Scenario 3	63	18 minutes

In Scenario 1, 60 patients are treated by the system during the experiment period; coordination nurse devotes 47 minutes per patient for coordination tasks. The realization time of each external actor is respectively 175 minutes for private nurse, 169 minutes for city biological laboratory, 253 minutes for family doctor and 22 minutes for hospital pharmacy. Ordinarily, family doctor should give the CGL before five o'clock p.m. in the first day of the process, but in 27% of cases, this deadline is not respected, which results in delay of chemotherapy drugs preparation in 28% of cases.

66 patients are received in Scenario 2. The coordination time per patient reduces to 32 minutes. There is no great difference compared with Scenario 1, in terms of realization time for most external actors, such as private nurse, city biological laboratory and hospital pharmacy. But family doctor uses less time: 187 minutes here against 253 minutes in Scenario 1, to fulfill his activity thanks to the first improvement solution. In the same way, the delay ratio drops from 27% to 5% for giving the CGL by family doctor, and from 28% to 5% for preparing chemotherapy drugs by hospital pharmacy.

Table 2. Comparative analysis actors between 3 scenarios in terms of realization of external actors' activities

Actors	**Activities realization**	**Scenario**		
		Scenario 1	***Scenario 2***	***Scenario 3***
Private nurse	Realization time	175 minutes	136 minutes	135 minutes
	Delays (%)	0%	0%	0%
Laboratory	Realization time	169 minutes	165 minutes	55 minutes
	Delays (%)	0%	0%	0%
Family doctor	Realization time	253 minutes	187 minutes	97 minutes
	Delays (%)	27%	5%	0%
Hospital pharmacy	Realization time	22 minutes	21 minutes	21 minutes
	Delays (%)	28%	5%	0%

For scenario 3, the system treats 63 patients during the experiment period. The coordination time drops to 18 minutes per patient. Thanks to an automatic communication way, the waiting time for information transmission is almost eliminated; the quality of coordination is thus improved. This way, for two external actors mostly concerned by information transfers, namely the city biological laboratory and the family doctor, we can observe a reduction of time: 55 minutes only for the first, and 97 minutes for the second. The delays observed previously disappear here completely.

To sum up, the current system is not optimal, coordination time is long and delays are important. Responsibility redefinition, accompanied with redundant tasks elimination, causes quality improvement of coordination and delay reduction for certain external actors. As expected, the implementation of a traceability management system of actors' activities permits an optimal coordination and eliminates all the delays. Though decline of the delay ratio between Scenario 2 and Scenario 3 is not significant (5%), the latter could reduce potential incidents caused by human with automatic information transfers; the quality of coordination is more secure, especially against a growth of activity in the future. However, other aspects should be designed before the system implementation, such as economic aspect and technical aspect, which requires further studies.

5 Conclusion

In this work, we are interested in chemotherapy at home system implemented by a HCS structure in France. A staff nurse is assigned especially for coordination task to ensure a smooth organization. We model and simulate the system to evaluate its performance.

An optimal coordination design permits less coordination time, which is not actually the case for the studied system. We therefore propose to redefine its coordination design in the first place and secondly to implement a traceability management system of actors' activities. According to comparative analysis of results, the latter leads the most optimal coordination.

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